Data from LACSD trawls were related to the coastal segments as follows: Data from transect T0 were used to estimate biomass densities for segment 3. Data from transect T1 were used to estimate biomass densities for segments 4, 4.5 and 5. Data from transect T4 were used to estimate biomass densities for segments 6, 7 and 8. Data from transect T5 were used to estimate biomass densities for segment 9.

White croaker and Dover sole biomass densities varied among depths. Depth is a dominant factor influencing the spatial distribution of soft-bottom fishes in this region (Allen 1982, Stull and Tang 1996). Moreover, there are distinct assemblages associated with inner, mid and outer shelf areas, roughly corresponding to <30m, 30-100m, and 100-200m. Accordingly, each coastal segment was divided into these three depth zones.

3.2.1.3. Temporal variation

The biomass densities of white croaker and Dover sole vary over time. Stull and Tang (1996) report temporal trends for many soft-bottom fishes, including white croaker and Dover sole, from 1973-93. Both white croaker and Dover sole were more abundant before than after 1980 (Stull and Tang 1996), but still varied substantially between 1980 and 2000. Plots of biomass density versus date for white croaker and Dover sole illustrate how biomass density has changed over time (Figure 3).

With white croaker, there is an indication of higher biomass density before 1985, with Mean ± SE equal to 5.26 ± 0.340 (N=240) before 1985 and 1.65 ± 0.061 (N=732) after 1985. This indication is somewhat supported by comparing catches with >10 kg of white croaker (Table 7). Twelve hauls with >10 kg of white croaker (4.2% of the total hauls during that period) were made from 1981-86. For the 1987-91 period, 7 of the hauls (2.9% of the total hauls in that period) yielded catches with >10 kg of white croaker. For the 1992-99 period, 11 of the hauls (again, 2.9% of the total hauls in that period) yielded catches with >10 kg of white croaker. Although there were proportionately more hauls with yields of >10 kg in the earliest period, the difference is slight and might not be biologically meaningful. Moreover, there are other periods with somewhat higher biomass densities, with one large haul in 1993. Looking at the data back to 1973, it appears that high abundances were found in 1977 on transect T5 at 23 m and 61 m depths and in 1983 on transect T5 at 23 m (Stull and Tang 1996). There were several periods of high abundance on transect T4 at 61 m, including 1974, 1978, 1983, 1987, and 1993. Because it is a schooling fish and its abundance is influenced by oceanographic events such as El Niño conditions (Stull and Tang 1996), it is difficult to discern a clear temporal trend in white croaker biomass density.

Figure 3. Biomass density (kg/ha) of white croaker and Dover sole for each trawl from 1980-2000. All transects and depths are combined in each panel.

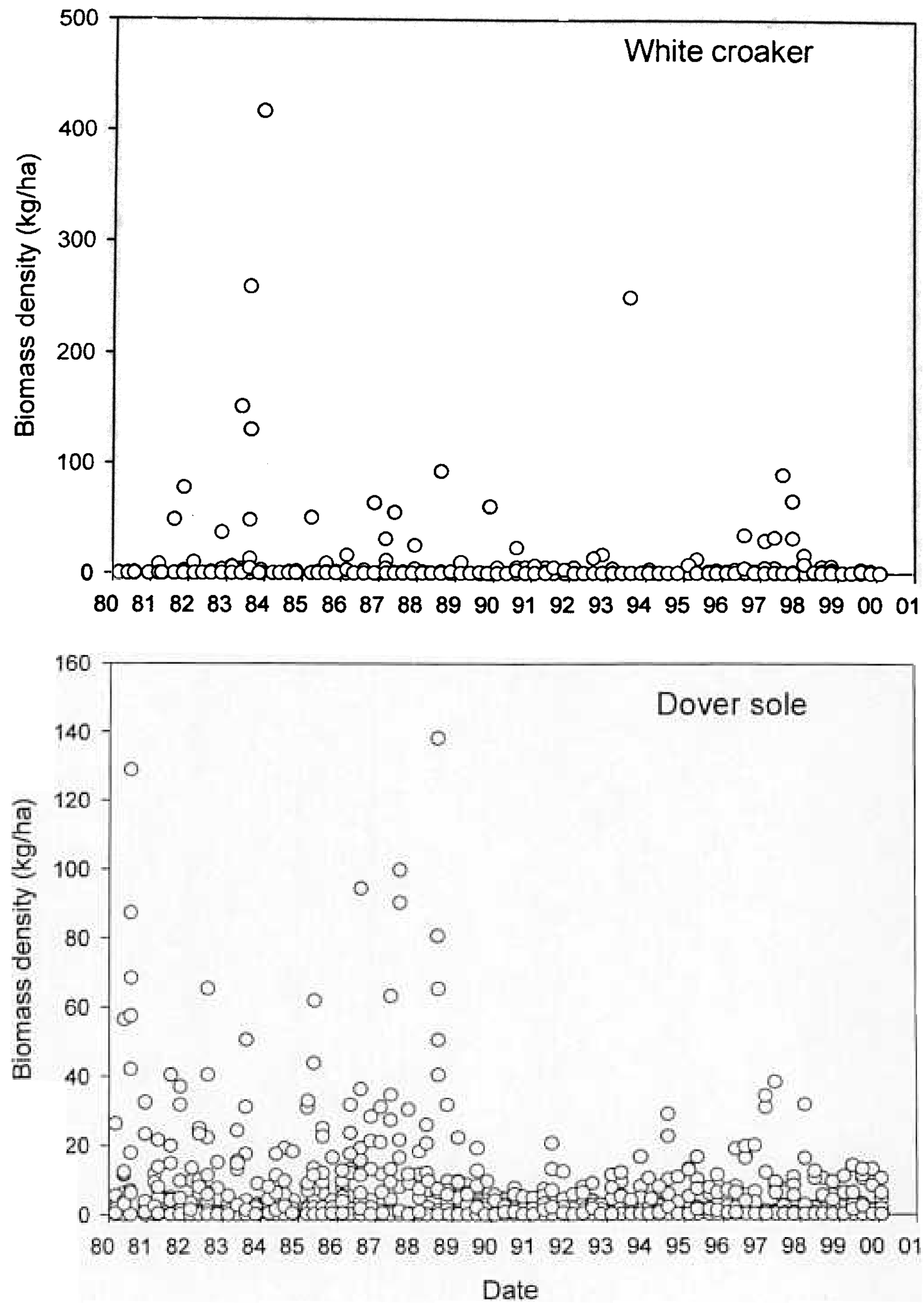


Table 7. Distribution of trawls with high catches of white croaker in different time periods.

Time period	Hauls >10 kg	
	Number	Proportion of Total Trawls
1981-1986	12	0.042
1987-1991	7	0.029
1992-1999	11	0.029

Dover sole biomass densities have also varied substantially, although it has been caught more consistently than white croaker. Dover sole biomass densities appeared to be generally lower after 1988, although there was a slightly increased catch in the late 1990s (Figure 3).

Because biomass densities varied over time but there was no clear, consistent pattern, I distinguish three time periods: 1981-86, 1987-91, and 1992-99. Having three time periods provided better temporal resolution to the standing stock estimates than having only one time period. The temporal resolution will allow for more accurate Resource Equivalency Analysis (REA) calculations. REA uses a discount factor to calculate damages in different years, so a low injury in early years will yield lower damages than a high injury.

3.2.1.4. Estimates of biomass densities for soft-bottom fishes

Biomass densities were calculated separately for each depth stratum at each transect and for each of the three time periods, 1981-86, 1987-91, and 1992-99.

Average biomass densities for white croaker and Dover sole are given in Table 1 and Table 2. Each mean is based on 24 trawls taken from 1981 to 1986, 20 trawls from 1987 to 1991, and 32 trawls from 1992-1999.

3.2.1.5. Habitat areas

To estimate the standing stocks of soft-bottom fish, the Palos Verdes Shelf was divided into segments 3 through 9 and three depth strata, as discussed in Section 3.2.1.2. Areas of each section were determined by digitizing maps in AutoCad and using Surfer Version 7 to calculate areas. The areas are given in Table 8.

The 30-100 m depth zone has the largest surface area, approximately 4,300 ha, followed by the inner shelf zone with nearly 3,100 ha and the outer shelf zone with 1,600 ha. Some of the <30 m depth stratum, which extends from the shoreline to 30 m, is covered with kelp (see Section 3.2.2.5); to calculate the area of habitat suitable for soft-bottom fishes, I subtracted the area of kelp in each segment from the total surface area in the segment.

Table 8. Substrate areas of three depth strata in the coastal segments in the Palos Verdes region.

	Surface Area Hectares				
Segment	<30 m	<30 minus kelp	30-100 m	100-200 m	Totals
3	1,151	1,008	1,022	710	3,892
4	427	333	1,458	448	2,666
4.5	290	250	414	146	1,101
5	198	181	317	83	779
6	241	221	267	114	843
7	322	254	355	77	1,008
8	238	197	303	74	812
9	214	181	259	71	725
Totals	3,051	2,595	4,325	1623	11,826

Coastal segment 3 has the largest area, nearly 3,900 ha, followed by segment 4 with nearly 2,700 ha. The other coastal segments are smaller, ranging from 725 ha to 1,101 ha. The overall surface area of the Palos Verdes Shelf region considered in this report is 11,826 ha.

3.2.1.6. Standing stocks for soft-bottom fish

Average standing stocks of white croaker and Dover sole were calculated by multiplying the biomass density (kg/ha) in each coastal segment/depth zone by the area (ha) of that segment/depth zone. Results are given in Table 1 for white croaker and Table 2 for Dover sole.

3.2.2. Rocky reef fish on the Palos Verdes Peninsula

The abundance and biomass of fishes living on rocky reefs has been assessed using diver surveys conducted by John Stephens (Vantuna Research Group), Dan Pondella, and co-workers. Fishes were counted quarterly from 1974-1999 at King Harbor and Palos Verdes Point following previously described protocols (Terry and Stephens 1976, Stephens and Zerba 1981, Stephens et al. 1984). For Palos Verdes Point, the annual mean densities for *Paralabrax clathratus* and *Embiotoca jacksoni* were calculated using a transect area of 240 m^2. Fishes were counted quarterly on five-minute timed swims 60 m in length, 4 m in width and 2 m above the substrate at four depths (10, 20, 30 and 40 feet) with three replicates per depth. All transects were used in the analysis. For *P. clathratus*, adults and subadults were counted together and juveniles were counted separately. For *E. jacksoni*, fish were categorized into three size classes following the classifications of Ebeling and Laur (1985): adults (>150 mm SL), subadults (100-150 mm SL) and juveniles (<100 mm SL).

In addition to the Palos Verdes Point analysis, data from Abalone Cove, Bunker Point and KOU reef (Pondella et al. 1996, Pondella and Stephens 1998) are also analyzed. These transects were conducted using the same methods as the Palos Verdes Point transects, but for fewer years.

3.2.2.1. Methods for calculation of biomass densities

Biomass estimates for the Palos Verdes Peninsula were calculated by D. Pondella using the following methods. Fish densities (number per hectare) were calculated from numbers of fish encountered by divers along transects of known area. To calculate the biomass of the adult fishes, the lengths of these fishes were determined using gillnets. Gillnet sets were conducted from 1995-1999 on the Palos Verdes Peninsula as part of field assessment for the Ocean Resource Enhancement Hatchery Program (Pondella and Allen *in press*). Histograms of standard lengths (SL) were constructed for each location on the Palos Verdes Peninsula. The mean sizes for the adults were calculated. For juvenile and subadult fishes, the median length of fishes for each size class was used in the analysis. Using these sizes, previously published weight-length relationships (Young 1963, Quast 1968, Love et al. 1987) were used to calculate the mean weight of the fishes. These power functions are of the form: $y = ax^b$, where y = weight, x = length. For *P. clathratus*, a = 0.00376, b = 3.27; however, Young (1963) gave lengths as total lengths in inches and weights in ounces. These data were transformed using standard conversions and the SL/TL equation TL = 1.41 + 1.20 SL (Love et al. 1996). For *E. jacksoni*, a = 8.266×10^{-6} and b =3.31179, with no further transformations needed (Quast 1968). Biomass was calculated by multiplying the generated mean weight values by the density values.

Since the mean standard lengths for Abalone Cove, Bunker Point and KOU reef (Pondella et al. 1996, Pondella and Stephens 1998) are basically the same as the overall mean values, the biomass analyses for these sites are identical.

The biomass density estimates rely on benthic visual transects in which fish are only counted if they are within 3 m of the substrate. Kelp bass, in particular, frequently occur above the substrate, and in kelp beds are distributed throughout the canopy (Stephens et al. 1984). In fact, kelp bass density in the water column can be substantially higher than benthic density in kelp beds (Ambrose 1987). My estimates of kelp bass biomass density, then, likely underestimate their actual biomass density. The estimates for black surfperch do not contain this bias because this species generally stays closely associated with the bottom.

Visual transects are widely used to provide estimates of fish density (number/ha) and biomass density (kg/ha), and they were used for many of the studies cited in this report (including Stephens et al. 1984, Ambrose 1987, DeMartini et al. 1989, Beers unpublished data). However, visual transects have been shown to underestimate fish densities (Davis and Anderson 1989). Therefore, the biomass densities estimated here probably underestimate true biomass densities. (Note, however, that the same is true for most data used in Section 4.1.1 for estimating the biomass densities of fish on artificial reefs.)

3.2.2.2. Spatial variation

The rocky reef fish data are presented according to the same coastal segments used for the soft-bottom fishes (Figure 1). The sampling locations were related to the coastal segments as follows: Data from Palos Verdes Point were used to estimate biomass densities for segments 3 and 4. Data from Abalone Cove were used to estimate biomass densities for segments 4.5 and 5. Data from Bunker Point were used to estimate biomass densities for segment 6. Data from KOU Reef were used to estimate biomass densities for segment 7.

There were no rocky reef fish data for reefs in segments 8 and 9, although suitable reef habitat occurs in those sections. There is no evidence of a clear spatial trend towards higher or lower densities in segments 8 and 9 compared to other areas of the Palos Verdes Peninsula. There does appear to be some influence of the Portuguese Bend landslide on nearby reef communities, and there is a suggestion of lower fish densities (especially kelp bass) at Abalone Cove and Bunker Point, the two stations nearest the slide area. To be conservative, I estimated biomass density in segments 8 and 9 by averaging the densities for all stations around the Peninsula, including Abalone Cove and Bunker Point. If there is any bias in this estimate, the estimate is likely to be too low because the reefs in segments 8 and 9 would be less influenced by the Portuguese Bend slide, and are more likely to be like the Palos Verdes Point of KOU sites.

3.2.2.3. Temporal variation

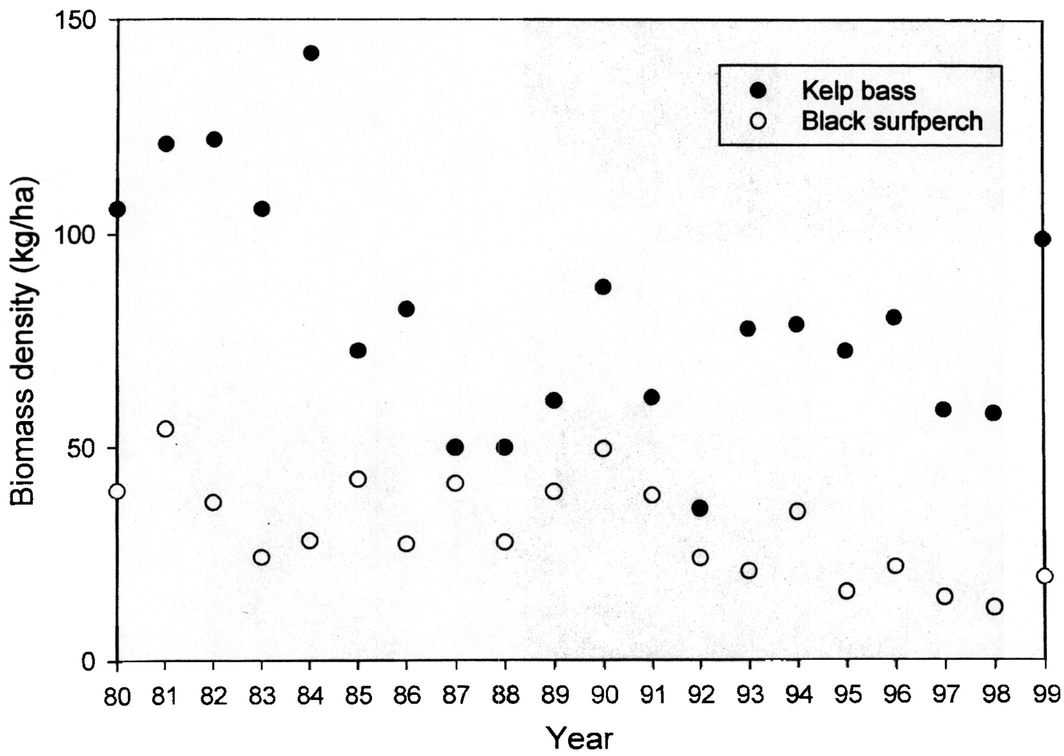
Like soft-bottom fish populations, rocky reef fish populations vary considerably through time. Temporal patterns in biomass densities for kelp bass and black surfperch at Palos Verdes Point were examined. Palos Verdes Point was the only study site with a long enough record to look for temporal patterns.

Both kelp bass and black surfperch biomass densities decline somewhat during the period 1980-1999 (Figure 4). Kelp bass biomass densities were higher from 1980-84, and then lower (and more or less without at trend, although there are fluctuations) thereafter. Black surfperch biomass densities were lowest from 1995-99.

3.2.2.4. Estimates of biomass densities for rocky reef fishes

Biomass densities were calculated for each of the four sampling locations along the Palos Verdes Peninsula (Palos Verdes Point, Abalone Cove, Bunker Point, KOU reef) for each of the three time periods, 1981-86, 1987-91, and 1992-96. (Biomass densities were not calculated for 1997-99 because there were no exceedance estimates for those years.)

Figure 4. Biomass density (kg/ha) of kelp bass and black surfperch at Palos Verdes Point from 1980 to 1999. Mean annual densities are shown.



Surveys were made in 1995-96 at Abalone Cove, 1997 at Bunker Point and 1997 at KOU Reef. These data were used to represent biomass densities for the entire period. No surveys were made at these sites between 1981-86 or 1987-91, so biomass densities for this period were estimated from existing data. Three approaches were considered. First, the relative difference between biomass densities in the different time periods at Palos Verdes Point could be used to adjust the 1992-96 data to estimate the earlier biomass densities. That is, temporal trends at Palos Verdes Point could be used to estimate earlier biomass densities at other sites. In both kelp bass and black surfperch, biomass densities at Palos Verdes Point were higher in the earlier period. For kelp bass, 1981-86 biomass densities were 1.6 times higher than 1992-96 biomass densities, and for black surfperch 1981-86 biomass densities were 1.5 times higher than 1992-96 biomass densities. Second, the relative difference between biomass densities at different sites compared to Palos Verdes Point in 1992-96 could be used to estimate the earlier biomass densities. That is, spatial patterns in 1992-96 could be used to estimate earlier biomass densities at other sites. Biomass densities at Palos Verdes Point were higher than at the other sites, except for kelp bass at KOU Reef. For example, kelp bass density in 1992-96 was 1.8 times higher at Palos Verdes Point than at Abalone Cove, and black surfperch was 1.3 times higher. Third, the 1992-96 data could be used directly as the estimate for the earlier biomass densities. This approach assumes there were no consistent spatial or temporal trends in biomass densities. Besides the data at Palos Verdes Point, which suggest there may have been temporal and spatial trends in abundance, I am not aware of any other data from the Palos Verdes Peninsula that could be used to evaluate the presence of spatial or temporal trends. However, data over the same time period for King Harbor do not indicate the same type of temporal trend as seen at Palos Verdes Point (J. Stephens, unpublished data). Because both of the other approaches would have given higher biomass density (and hence injury) estimates, and there was no clear evidence for consistent temporal or spatial trends in biomass density among the Palos Verdes sites, I adopted the third approach. The estimates I use most likely provide a lower bound of the true values.

Estimated average biomass densities for kelp bass and black surfperch are given in Table 3 and Table 4. The mean for Palos Verdes Point is calculated from annual means, which are based on quarterly samples. Means for other sites based on fewer samples: 18 transects in 1995-96 for Abalone Cove, 8 transects in November 1997 for Bunker Point, and 10 transects in November 1997 for KOU Reef.

3.2.2.5. Habitat areas

To estimate the standing stocks of rocky reef fish, the Palos Verdes Shelf was divided into segments 3 through 10, as discussed in Section 3.2.1.2. Although there are rocky areas throughout the Shelf area deeper than 30 m (J. Gardner, USGS, personal communication), I have confined my analysis to the shallow (<30 m deep) rocky reefs along the shoreline.

No comprehensive surveys have been made to determine rocky reef areas in the Palos Verdes region. As a proxy for reef area, I have used the area of giant kelp (*Macrocystis pyrifera*) beds, estimated by the area of the surface canopy. In the Palos Verdes area, giant kelp occurs only on hard substrate, so the occurrence of giant kelp is a good indicator of where hard substrate occurs. Although soft bottom areas may occur underneath a kelp surface canopy, they are likely to consist of small patches of sand interspersed in a rocky area (large sand patches would lead to a gap in the canopy), and hence be part of a reef system. Although giant kelp generally occurs only where there is hard substrate, the converse is not necessarily true: there is a great deal of hard substrate with no giant kelp. Thus, using the area of giant kelp as an indicator of rocky reef area will substantially underestimate the actual reef area. The areas that do not support giant kelp will nonetheless support the target rocky reef species. No studies have been conducted at Palos Verdes Peninsula to allow a quantitative assessment of the likely magnitude of error as a result of estimating rocky reef area from kelp surface canopy area. However, in other regions in Southern California kelp may cover only half of the rocky substrate on a reef (J. Bence, personal communication). The use of kelp surface canopy may substantially underestimate the actual amount of rocky reef in an area, and thus the standing stock of rocky reef fish in the area may also be underestimated.

Data on kelp surface canopy areas at Palos Verdes have been collected by the California Department of Fish and Game (CDF&G) from 1974 to 1997, and graphed in the LACSD 1997 Annual Report. These data indicate a maximum kelp area in 1989. I